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Multiresource Inventories: Woody Biomass in North Carolina

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ABSTRACT

North Carolina's 31.2 million acres of land area support 1.7 billion tons of woody biomass. Of this total, 94 percent is on timberland, 3 percent on nonforest areas, and 3 percent on reserved timberland and woodland areas. Over the next two decades, more than 12.8 million tons of woody biomass could be harvested annually from timberland without adversely affecting timber supplies.

Keywords: Growing stock, timberland, multiple use.

Wood is being used as a source of energy for both domestic and industrial needs. There is considerable interest in any opportunity to rid timberland of vast quantities of wood and bark in low-quality trees. There is also concern that large-scale use of wood for energy could jeopardize supplies of growing stock counted on for other products. Although this uncertainty makes it difficult to differentiate between energy wood and growing stock, it is imperative that the quantity, composition, distribution, and prospective availability of total woody biomass be evaluated.

Traditionally, State and regional forest inventories have been designed to estimate the volume of wood from a 1-foot stump to a 4.0-inch top diameter outside bark (d.o.b.) for trees 5.0 inches and larger in diameter at breast height (d.b.h.). Recently prepared statistical reports for North Carolina focus primarily on volume of growing-stock timber measured to these standards (Bechtold 1985; Craver 1985; Davenport 1984; Hutchins 1985; Sheffield and Knight 1986; Tansey 1984). Because of the growing interest in woody biomass as a source of energy, however, the additional amount of wood and bark in all trees on timberland and the total wood and bark biomass on reserved timberland and woodland and nonforest areas must be analyzed.

Forest Inventory and Analysis (FIA) at the Southeastern Forest Experiment Station is in a particularly favorable position to make a statewide biomass assessment because it has a permanent set of sample plots uniformly scattered across all forest and nonforest areas in North Carolina, Virginia, South Carolina, Florida, and Georgia. The advantages in having permanent sample plots are that they can be revisited, subsampled, or used as a proportionate sample of the entire area base.

Woody biomass is defined as the green weight of aboveground wood and bark in live trees 1.0 inch d.b.h. and larger, from the ground to the top of the tree. All foliage is excluded. The weight of wood and bark in lateral limbs, secondary limbs, and twigs less than 0.5 inch in diameter at the point of occurrence on sapling-size trees is included, but that on poletimber and sawtimber-size trees is excluded. The primary objective of this study is to present the distribution and quantity of woody biomass on forest lands and nonforest areas. Other objectives are to compare total biomass including bark, as defined, with conventional growing stock; to quantify the unutilized sources of forest biomass in recently

harvested areas where wood is left as residues; and to identify stands in need of regeneration. Finally, this study also identifies new opportunities for studying forest yields in terms of site, stocking and age classes, timber utilization, and successional trends.

Methods

The 1984 multiresource inventory of North Carolina provided a full array of biomass data from all lands in North Carolina. The techniques and procedures used are not the only methods available, but their value has been demonstrated in the most recent biomass inventory of Florida (Cost and McClure 1982). The method of inventory is a sampling procedure designed to provide reliable area, volume, growth, and removal statistics primarily at the State and Survey Unit levels. Little is known about degree of precision or number of samples needed for biomass inventories. Since these guidelines were lacking, this biomass evaluation is for the entire State to minimize sampling errors.

Within forest land, numbers of trees, sizes, and quality were recorded at each sample plot. Trees 5.0 inches d.b.h. and larger were measured at 3 to 5 points where variable-radius plots were defined by a prism with a basal area factor of 37.5. Trees less than 5.0 inches d.b.h. were tallied on 1/300-acre plots around the point centers. Biomass measurements were recorded at 5,355 timberland locations, 46 reserved timberland locations, and 12 woodland locations across the State. From a crown closure stratification of all nonforest plots, 277 subsample locations representing different crown closure classes and land uses were visited on the ground. At each location the number of trees 1.0 inch d.b.h. and larger, species associated with nonforest uses and occurring as narrow stringers, and small patches of forest and remnant parcels of forest land not qualifying as timberland were recorded on a 1-acre circular plot. These sample counts were expanded to represent the total population of trees on land classified as forest and nonforest. Volume equations, based on detailed measurements of standing and felled trees in North Carolina and on similar measurements taken from other trees throughout the Southeast, were used to compute merchantable and total cubic volume (Cost 1978). Weight equations provided by the Utilization of Southern Timber Research Unit of the Southeastern Forest Experiment Station in Athens, GA, made it possible to convert volume to weight. The procedures used for collecting and reporting detailed biomass data were outlined by Saucier (1979) and Clark (1979).

Sheffield and Knight (1986) described timberland in terms of six broad management classes: (1) nonstocked forest, (2) pine plantation, (3) natural pine, (4) oak-pine, (5) upland hardwood, and (6) lowland hardwood. Nonstocked forest is timberland less than 16.7 percent stocked with growing-stock trees. The other broad management classes are based on forest type, determined by the stocking of all live trees. In all stands where pines made up a plurality of the stocking, the broad management class was either pine plantation or natural pine. These two classes were differentiated by stand origin. Where there was evidence of planting or artificial regeneration, the stand was classified as a pine plantation. Oak-pine was the classification assigned to stands where hardwoods accounted for a plurality of the stocking but in which pines made up 25 to 50 percent of the stocking. In all other stands, hardwoods and cypress constituted a plurality of the stocking, and forest type was used to distinguish between upland and lowland hardwood classes. Oak-hickory and scrub oak types were classified as upland hardwood. Oak-gum-cypress and elm-ash-cottonwood forest types were classified as lowland hardwood.

Since assignment of forest types is based on the stocking of all live trees except those overtopped rather than on the stocking of growing-stock trees, the broad management classes are even more meaningful in the evaluation of biomass. In this study of woody biomass, the broad management class "nonstocked forest" used

in the timber evaluation was distributed among the other classes, based on forest type. Although these stands contain insufficient growing stock to be considered stocked, many contain substantial amounts of biomass in rough and rotten trees.

Acreage of timberland, by broad management classes, was further defined by stand-age classes. Ten-year age classes were selected for this analysis since very little merchantable-size timber accrues in a stand before age 10 and many pine stands are managed on 30-year rotations. Stand-age data were collected to the year rather than in classes; therefore, any age-class distribution could have been selected. There are difficulties in determining a meaningful age in some natural stands. An understanding of these difficulties is important to the interpretation and use of some of the empirical data on yields of forest biomass presented in this report.

Often natural timber stands are a mixture of residual trees from a former stand and of younger trees established following the most recent harvest or disturbance. In these cases, field crews recorded the average age of trees of common origin that accounted for a plurality of the stocking as long as they were of sufficient number to form a manageable stand for timber production--normally 60 percent or more of the minimum number required for full stocking. Where insufficient trees of common origin were present for a manageable stand, the age was based on all trees present.

Also, the acreage within each broad management class was further broken down by site and stocking class. The stocking classes were based on all live trees rather than on growing stock. Average green weight of woody biomass per acre was compiled for each subdivision. The weight equations used were sensitive to species, d.b.h., and total height. There may be additional variation in weight attributable to geographical differences, stand origin (planted vs. natural), or tree section that would not be reflected in this study.

Results and Discussion

Total Biomass

The quantity of biomass in each broad use category is highly dependent upon the acreage within the State as well as on the concentration of material on these acres. In interpreting biomass quantities, therefore, it is helpful to know how many acres are in each category.

Use category	Thousand acres	Percent
Timberland	18,450.3	59
Reserved timberland and woodland	502.6	2
Nonforest	12,275.3	39
Total	31,228.2	100

The 31.2 million acres of timberland, reserved timberland and woodland, and nonforest land in North Carolina support more than 1.7 billion tons of woody biomass. Figure 1 shows the distribution of biomass by land use category.

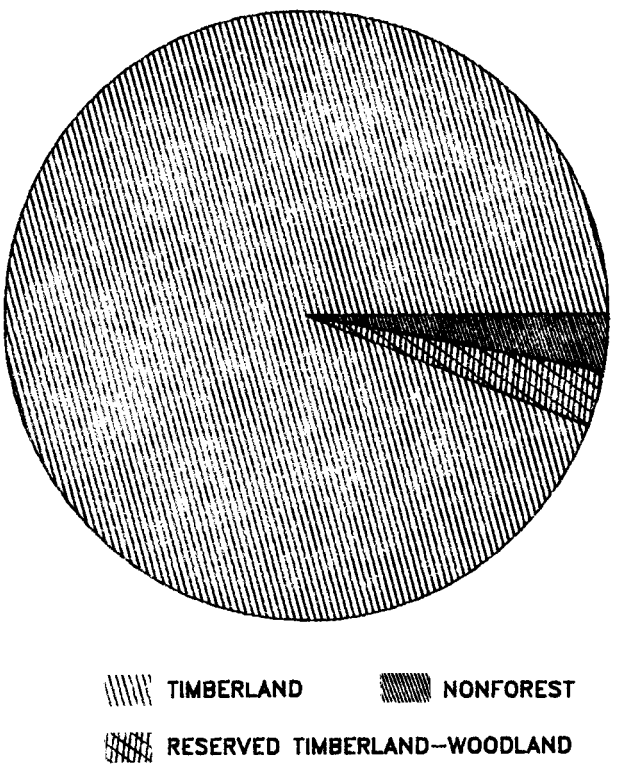

Figure 1.--Percentage distribution of green weight of aboveground woody biomass, by land class, North Carolina, 1984.

Timberland Biomass Resource

A compilation of acreage of timberland, by broad management and stand-age classes, provides a good basis for examining the quantity, composition, distribution, and prospective availability of woody biomass in North Carolina (table 1). Table 1 shows a large concentration of pine plantations between 0 and 30 years old and natural pine between 21 and 50 years old.

During the late 1950's and early 1960's, extensive acreage was planted under the Conservation Reserve Soil Bank Program. During this era, extensive acreage of idle cropland reverted naturally to pine stands. Since about 1974, North Carolina has experienced a sharp reduction in acreage of idle cropland reverting to forest. Tree planting on old fields also decreased sharply following the termination of the Soil Bank Program. The acreage figures for natural pine stands in table 1 reflect these changes in land use.

For the oak-pine and upland hardwood stands, the greatest acreage is in the stand-age classes from 31 through 70. Many of these stands are on sites that previously supported pine, but where pine was not adequately regenerated at the time of harvest. Both lowland and upland hardwood stands account for over 80 percent of all stands 71 years old and older. Most of these stands are located throughout the Mountains on steep slopes and in the Coastal Plain in deep swamps. Over the years, the large and good-quality trees have been high graded from these stands, leaving the smaller and poorer quality trees.

Total biomass and biomass of conventional growing stock. For the 18.5 million acres classified as timberland, green weight of conventional growing stock averaged 59.4 tons per acre (table 2); for total woody biomass, the average was 88.6 tons per acre, or 49 percent more (table 3). By broad management class, the largest difference between average weight of conventional growing stock and total woody biomass per acre was found in hardwood stands. Across all ages combined, average weight of total biomass exceeded average weight of conventional growing stock by 31 tons per acre, or 50 percent, in upland hardwood stands. In lowland hardwood stands, the average weight difference was more than 38 tons per acre.

Table 2 provides measures of the average accumulation of biomass within each broad management class over time. As one would expect, conventional growing stock accumulates somewhat faster in pine stands, especially pine plantations, than in oak-pine and hardwood stands. Control over both species composition and spacing in pine plantations shortens the time required to grow merchantable timber products. By broad management class across all age classes, average weight of conventional growing stock ranged from a low of 28.7 tons per acre in pine plantations to a high of 71.5 tons per acre in lowland hardwood stands.

Table 3 shows that natural pine, oak-pine, upland hardwood, and lowland hardwood stands keep pace with the more intensively managed pine plantations in production of biomass up to age 10. Beyond age 10, woody biomass accumulates much faster in the intensively managed pine plantations. The low overall average for pine plantations is attributed to the large proportion (99 percent) of these stands that is less than 31 years old. On the other hand, more than 72 percent of the lowland hardwood stands were 31 years old or older. The relatively low production of biomass indicated for the oak-pine management class can be attributed in part to the origin of many of these stands. A large portion of this acreage supports sparsely stocked conditions on upland sites left following the harvest of former pine stands.

Living logging residues. As part of the inventory in North Carolina, field crews at each sample location noted the primary treatment or disturbance in evidence that had occurred between 1974 and 1984. Sheffield and Knight (1986: tables IV, V) reported the results, by broad management and ownership classes. As part of this evaluation of woody biomass, these acreage estimates were recompiled, eliminating ownership class (table 4).

During the 1974-84 period, almost 600,000 acres annually experienced significant treatment or disturbance, and timber harvesting was the most common forestry activity observed. On the average, slightly more than 206,000 acres underwent a final harvest annually, exclusive of intermediate cutting, commercial thinning, harvesting with artificial regeneration, and land clearing. Green weight of woody biomass left in standing trees for these harvested stands averaged 24.2 tons per acre (table 5).

Since all of these treatments occurred during the remeasurement period, one can assume that measures of average biomass per acre reflect the quantities some 5 years after the treatment in cases of harvesting, thinning, and planting. It is important to keep in mind that broad management classes describe the forest type at the beginning of the remeasurement period rather than at the end. By broad management class, average weight of woody biomass that was left following other harvesting ranged from 12.8 tons per acre in pine plantations to 29.7 tons per acre in upland hardwood stands. Much of the biomass in these stands is in rough, rotten, and small trees that compete for growing space, thereby inhibiting the development of a productive new stand. An examination of these stands shows that they average 499 stems per acre. Figure 2 shows that more than 89 percent of these trees are 1.0 and 5.0 inches d.b.h.

The low average for plantation biomass reflects areas clearcut, site prepared, and planted within the 10-year period. The high average for upland hardwood reflects quantities of biomass left after high grading of these stands within the same period.

The 24.2 tons per acre of woody biomass following other harvesting (table 5) include only material in living trees. Stumps, tops, and limbs of cut trees left as conventional logging residues are excluded. Even in pine plantations, substantial quantities of such residues are commonly pushed up into windrows when there is intensive site preparation following harvesting.

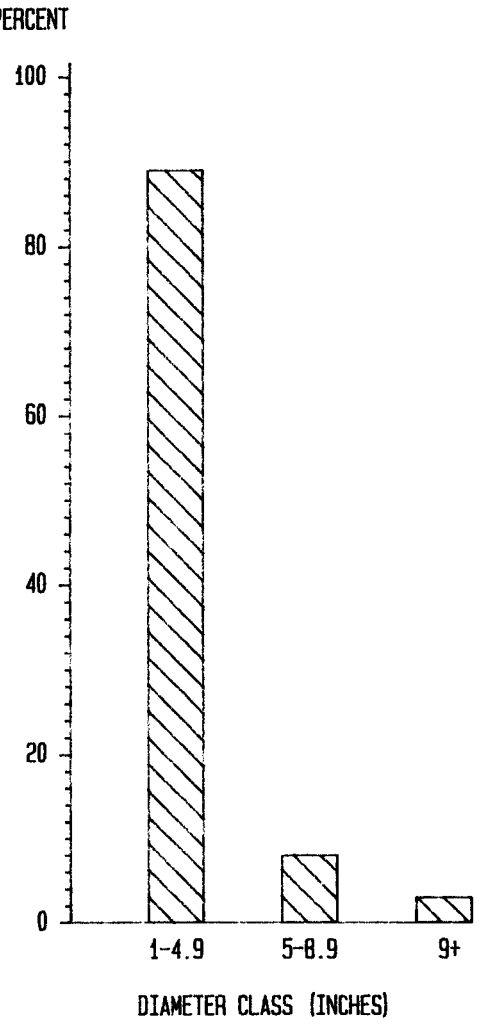

Figure 2.--Distribution of living residues in harvested stands, by diameter class, North Carolina, 1984.

Poorly stocked stands. Field crews noted obvious opportunities for increasing prospective timber growth on sample plots. Sheffield and Knight (1986: table VII) show acreages providing these management opportunities. For our study we recompiled the acreage, eliminating ownership class and idle cropland, and redistributed nonstocked forest among the other management classes (table 6).

There are 2.0 million acres of timberland in North Carolina too poorly stocked with acceptable trees to manage for timber production. These acres represent the backlog of needed regeneration on manageable sites in North Carolina. They contained an average of 33.2 tons of woody biomass per acre (table 7). Biomass on these poorly stocked acres

comprised mostly rough, rotten, and other low-quality trees. The biomass in these stands can be characterized much like the biomass in recently harvested stands. On the average, these stands contain 489 trees per acre. More than 85 percent of the trees are between 1.0 and 5.0 inches d.b.h., and three-fourths of the biomass is in hardwood. Altogether, these acres contained about 4 percent of the total woody biomass in the State. Practically all of this biomass could be removed and used for energy without adversely affecting prospective timber supplies.

Another 218,000 acres supported manageable stands but will contribute very little net annual growth unless converted to species more suitable to the sites. Such areas contained an average of 54.7 tons of woody biomass per acre.

Over 59,000 acres supported seriously damaged stands that needed to be salvaged and regenerated. These stands contained substantial volume of merchantable timber seriously damaged by fire, insects, disease, wind, ice, or other destructive agents. Woody biomass in these stands averaged 123.2 tons per acre, plus an undetermined amount of wood and bark in dead trees.

Finally, about 2.3 million acres of immature stands were too densely stocked with small, merchantable-size trees or were receiving serious competition from rough trees or other inhibiting vegetation. Without some treatment, growth of these stands quite likely will be reduced by suppression. Biomass removed during thinning or cleaning represents another source of energy wood that would not adversely affect prospective timber supplies.

More than 67 percent of the woody biomass in North Carolina was either in stands in good condition needing no treatment or in stands growing on sites limited by year-round water problems. More than 9.1 million acres supported immature stands in relatively good condition. These stands are at least 60 percent stocked with trees of acceptable quality and free from significant damage or competition. On these acres, biomass averaged 82.1 tons per acre. An additional 2.8 million acres supported stands with year-round water problems or on slopes of at least 40 percent. On these adverse sites, woody biomass averaged 119.7 tons per acre. Annually, since 1974, less than 1 percent of these sites have experienced any cutting or treatment. Hardwood stands accounted for the largest portion of these sites. Such stands probably will not be cut in large quantities at any particular time.

About 33 percent of the woody biomass in North Carolina is in stands where prospective energy wood could be harvested without adversely affecting timber supplies.

Rough and rotten trees. North Carolina's timberland supported 1,638.4 million tons of woody biomass in 1984. Growing-stock trees accounted for 89 percent of the woody biomass (table 8). The remaining 11 percent was in trees 1.0 inch d.b.h. and larger which failed to meet minimum standards for growing stock because of species, poor form, or roughness. Theoretically, this biomass could be removed without adversely affecting existing and prospective supplies of timber. Over 40 percent of the biomass in rough and rotten trees 5.0 inches d.b.h. and larger was in the bole portion. This biomass could be harvested with conventional equipment. The remaining 60 percent was in saplings, stumps, tops, and limbs and would require specialized harvesting methods.

Other potential sources of woody biomass are stumps, tops, and limbs of growing-stock trees 5.0 inches d.b.h. and larger. Since this material would normally not be available before harvest, the 14 percent of woody biomass in stumps, tops, and limbs of growing-stock trees in table 8 probably overestimates the amount of this kind of material at any given point. From a practical standpoint, the 8 percent biomass in growing-stock saplings should not be counted in estimates of energy wood as this is needed to replace current growing-stock supplies.

Table 8 simplifies the comparison of growing stock and total woody biomass among the major species groups. For

example, hardwoods account for more than 64 percent (936.9 million tons) of the total biomass of growing stock but for 68 percent (1,114.9 million tons) of the total woody biomass.

Totaling energy biomass. A few reasonable assumptions are required to estimate the amount of woody biomass that could be harvested for energy in North Carolina. The 2.0 million acres of poorly stocked timberland classified as offering a regeneration opportunity are the primary source of energy wood that could be harvested without adversely affecting prospective timber supplies. This area supports more than 33 tons of woody biomass per acre. If 5 percent of this acreage (101,127) is cleared each year and an average yield of 33.2 tons per acre is assumed, some 3.4 million tons of energy wood could be harvested annually from these lands during the next 20 years.

The second major source of prospective energy wood is available on the more than 206,000 acres of timberland harvested annually. This area supports more than 24 tons per acre of woody biomass left standing after harvest. If an average of 24.2 tons per acre is assumed, 5.0 million tons of additional energy wood could be harvested annually from these living residues. Based on FIA plot remeasurement data and utilization studies, it is estimated that the weight of logging slash and logging residues remaining in recently harvested stands in Georgia is equivalent to 21.1 tons per acre. A breakdown of this total shows conventional logging residues represent about 31 percent, or 6.5 tons per acre. Logging slash is the unmerchantable portion of growing-stock trees (including saplings) plus all cull trees 1.0 inch d.b.h. and larger cut or destroyed during logging operations and not used. These represent 69 percent of the total, or 14.6 tons per acre. If an average of 21.1 tons per acre is assumed, 4.4 million tons of additional energy wood could be harvested annually from these living residues in North Carolina. It should be noted that these weights do not include those residues available from stands experiencing cultural practices other than harvest.

Based on these assumptions, at least 12.8 million tons of energy wood could be harvested annually over the next 20 years in harmony with conventional forestry practices and opportunities. On a green weight basis, this tonnage of energy wood is about 59 percent of the total harvest of industrial products in North Carolina in 1983.

Hardwood in pine stands. On North Carolina's 4.7 million acres of natural pine, woody biomass consisted of 73 percent yellow pine, 23 percent hardwood, and 4 percent other softwoods (table 9). Many pine stands between 10 and 40 years old were established on idle cropland relatively free of hardwood root stocks. Yellow pine accounted for a higher proportion of the biomass in these stands than in pine stands less than 11 years old. Many pine stands established more recently were installed on cutover forest land where the hardwood root stocks are entrenched. Even with intensive site preparation for planted pine, hardwoods make up 19 percent of the woody biomass in stand-age class 0-10. In oak-pine stands where pines account for only 25 to 50 percent of the stocking, the pine biomass makes up only 34 percent of the total biomass. Pine makes up only 4 percent of biomass in upland hardwood and 3 percent in lowland hardwood stands. These statistics bear out the region's natural successional trends.

Large trees in young stands. As stated earlier, natural pine, oak-pine, upland hardwood, and lowland hardwood stands are keeping pace with the more intensively managed pine plantations in production of biomass up to age 10. Table 10 provides some indication of how this has occurred. More than 69 percent of the total biomass in pine plantation 0-10 years old was in trees less than 5.0 inches d.b.h. Only an average of 32 percent of the trees in young natural pine, oak-pine, upland hardwood, and lowland hardwood stands were in the smallest size class. A significant proportion of the biomass in the hardwood stands is in larger trees that were left during harvests of former stands. The large trees in the 0-10 age class in natural pine and oak-pine stands also are residuals from former stands.

Site and stocking affect yield. Within each management class, the production and distribution of woody biomass in North Carolina by site, stocking, and age class is examined. The site classes are those used in the timber evaluation. Good sites are those capable of annually producing timber growth of 85 cubic feet or more per acre in fully stocked natural stands; medium sites, 50 to 85 cubic feet; and poor sites, 20 to 50 cubic feet. The stocking classes are based on all live trees rather than growing stock:

Stocking class	Stocked (percent)
Fully stocked	100 or more
Medium stocked	60-100
Poorly stocked	Less than 60

Tables 11 to 15 show the distribution of acreage within each broad management class by site, stocking, and age class. Statewide, over 65 percent of the timberland was fully stocked. A breakdown of site classes for timberland across the State shows 87 percent of the area to be either good or medium sites. Among the five broad management classes, lowland hardwood stands have the highest proportion of good sites, with a high of 38 percent compared with a low of 30 percent for pine plantations. On the other hand, pine plantations had the highest proportion of fully stocked stands, with a high of 78 percent compared with a low of 56 percent for upland hardwood stands. The low averages for upland hardwood stands reflect both the acreage of scrub oak included in this management class and inadequate regeneration efforts after harvest.

Tables 16 to 20 show the average green weight of woody biomass per acre within each broad management class by site, stocking, and age class. Since more than 98 percent of pine plantations were less than 31 years old, the relatively low value of 46 tons per acre for the 1.6 million acres of planted pine is not surprising (table 16). The number of sample plantations established before the Soil Bank era was too small to estimate yields beyond the 41-50 age class. Results show that fully stocked good sites will yield 100 tons of biomass per acre in 30 years.

The 4.7 million acres of natural pine contained an average of 88 tons of biomass per acre (table 17). Fully stocked natural pine stands on good sites produced more than 100 tons of biomass per acre in 30 years. For all age classes, fully stocked natural pine stands on good sites produced about nine times more biomass than did the poorly stocked stands on poor sites.

The average biomass on the 2.3 million acres of oak-pine was 80 tons per acre (table 18). Many of these stands are on sites from which pines were harvested but not adequately regenerated. Biomass yield data presented in table 18 reveal that fully stocked oak-pine stands on good sites can achieve 100 tons per acre in 40 years. For all age classes, fully stocked oak-pine stands on good sites produced over nine times more biomass than did the poorly stocked stands on poor sites.

Upland hardwoods occupied more than 7.1 million acres. Like oak-pine, many of these stands are on sites that previously supported pine. Since a large percentage of upland hardwood stands are more than 30 years old, their combined woody biomass averaged 93 tons per acre (table 19). Many of these stands are on sites that were harvested but not adequately regenerated. Results show, however, that fully stocked upland hardwood stands between 31 and 40 years old and on good sites will produce 100 tons of biomass per acre; in all age classes, fully stocked stands on good sites produce over six times more biomass than the poorly stocked stands on poor sites.

Finally, the 2.7 million acres classed as lowland hardwood contain more than 109 tons per acre (table 20). This management class alone makes up 18 percent of North Carolina's woody biomass. The high weight is attributed to the large proportion (72 percent) of these stands that are 31 years of age or older. Also, more than 68 percent of the stands were fully stocked. Fully stocked lowland hardwood stands between 31 and 40 years old and on

good sites will yield 100 tons of biomass per acre. For all age classes combined, these stands contained about 12 times more biomass than the poorly stocked stands on poor sites.

Reserved Timberland and Woodland Biomass Resource

North Carolina's 0.5 million acres of reserved timberland and woodland support about 52.5 million tons of wood and bark in trees 1.0 inch d.b.h. and larger. For analysis, each of these areas is further classified by forest type (table 21).

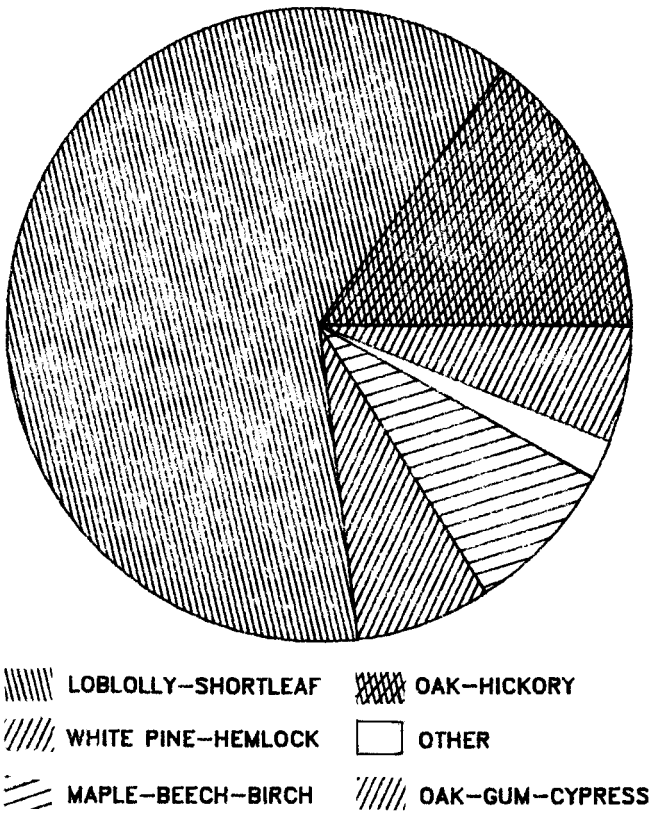

Figure 3.--Percentage distribution of woody biomass on reserved timberland, by forest type, North Carolina, 1984.

Figure 3 shows that 68 percent of more than 459,000 acres of reserved timberland is classified as oak-hickory and accounts for 62 percent of the woody biomass. More than 85 percent of these forests are located in the Mountains, mostly in the Great Smoky Mountains National Park and wilderness areas on National Forests. Yellow pine types make up 12 percent of the acreage and account for about 15 percent of the biomass. Maple-beech-birch is the third leading type, accounting for 8 percent of both the acreage and biomass. Oak-gum-cypress, white pine-hemlock, spruce-fir, and oak-pine make up the remainder of acreage and woody biomass.

On woodland, oak-gum-cypress stands make up about one-half of the acreage and account for 72 percent of the biomass on these lands.

Table 21 shows the average green weight per acre, by forest type. On reserved timberland the woody biomass averaged 113 tons per acre. By forest type, the average weight per acre ranges from a low of 74 tons in spruce-fir stands to a high of 157 tons in white pine-hemlock stands; however, these latter stands support only 6 percent of the woody biomass because of the small acreage in this type.

Nonforest Biomass Resource

Up to this point we have quantified the woody biomass on all forest lands in North Carolina. To make a comprehensive evaluation of total biomass for the State, we need to evaluate the biomass associated with nonforest land uses. In many cases this associated biomass takes on the appearance of forest land but does not qualify because of size or configuration. Good examples are strips or stringers along highway medians, riparian zones, isolated trees in pastures, trees along a fence row, or trees in city parks.

To aid in the stratification of woody biomass on the nonforest lands, a crown closure code, which reflects the per acre stocking of trees 1.0 inch d.b.h. and larger, was assigned to each plot. For example, a crown closure of zero would indicate no biomass. At field points, 10 percent crown closure classes are recognized. For this analysis we developed three classes: 1-29, 30-59, and 60+ percent.

North Carolina's 12.3 million acres of nonforest area represent about 39 percent of the total land area of the State and support over 43 million tons of woody biomass. Of the 12.3 million acres, only 3.7, or 3 out of every 10 acres of nonforest land, have woody biomass. Table

22 shows that 46 percent of the nonforest area consists of urban and other; 20 percent, cropland; 18 percent, improved pasture; 9 percent, other farmland; 5 percent, idle farmland; and 2 percent, marsh and water.

More than 8.6 million acres, or 70 percent, of the nonforest land in North Carolina have no woody biomass. The majority of this nonforest land (76 percent) is currently being used for agricultural crops and improved pasture.

Table 23 shows the average tons per acre by crown closure. For nonforest areas with woody biomass (3.7 million acres), the average weight per acre ranged from 6 to 40 tons. For all nonforest areas, the woody biomass averages about 12 tons per acre.

About 2.7 million acres of nonforest land have a crown closure class of 1-29 percent. The nonforest uses within this class contain an average of 6 tons per acre. By land use, average weight of woody biomass ranged from 4 tons per acre for other farmland to 10 tons per acre for both improved pasture and noncensus water. The biomass associated with noncensus water is primarily in trees standing along canals and on margins of ponds.

Another 0.7 million acres of nonforest land have crown closures averaging 30-59 percent. Woody biomass in these nonforest uses averages 22 tons per acre. By land use, average weight of biomass ranged from 16 tons per acre for noncensus water to 24 tons per acre for improved pasture.

Finally, more than 0.3 million acres of nonforest land have crown closures of 60+ percent. These nonforest uses contain an average of 40 tons per acre. By land use, average weight of woody biomass ranged from 17 tons per acre for idle farmland to 68 tons per acre for cropland. The biomass associated with cropland is mainly in trees in small tracts of forest less than 1 acre that is interspersed between nonforest uses.

Table 24 shows the distribution of forest biomass, by land use and selected species groups. Yellow pine is the leading species in terms of total biomass, followed closely by the oaks. Both the yellow pine and oaks combined represent over 61 percent of the total biomass. By land use, urban and other uses support the largest amount of woody biomass with 53 percent of the total weight; improved pasture supports 19 percent; cropland, 14 percent; other farmland, 9 percent. The remaining 5 percent is distributed among idle farmland, marsh, and noncensus water.

Conclusions

Several conclusions can be drawn about the quantity, composition, distribution, and prospective availability of woody biomass in North Carolina in 1984.

North Carolina's 31.2 million acres of land area support 1.7 billion tons of woody biomass. Timberland supports 1.6 billion tons of biomass, or an average of 89 tons per acre; reserved timberland and woodland support over 52 million tons, or an average of more than 104 tons per acre; and nonforest land having woody biomass supports over 43 million tons, or an average of 12 tons per acre.

Within timberland the total woody biomass on a per acre basis exceeded the green weight of conventional growing stock by 49 percent. Conventional growing stock accumulates somewhat faster in pine stands, especially in pine plantations, than in oak-pine and hardwood stands. By broad management class across all age classes, average weight of conventional growing stock ranged from a low of 28.7 tons per acre in pine plantations to a high of 71.5 tons per acre in lowland hardwood stands.

Annually, since 1974, over 206,000 acres experienced a final harvest and are not artificially regenerated. This average excludes commercial thinning, other intermediate cutting, and land clearing. Woody biomass left in standing trees after harvest averaged approximately 24.2 tons per acre. An examination of these stands shows that more than 89 percent of the trees are between 1.0 and 5.0 inches d.b.h.

More than 2.0 million acres of timberland were too poorly stocked with acceptable trees to manage for timber production unless regenerated. This acreage supported an average of 33.2 tons per acre of woody biomass composed mostly of rough, rotten, and other low-quality trees, although these acres accounted for about 4 percent of the total biomass. Most of this biomass could be removed and used for energy without adversely affecting prospective timber supplies.

About 33 percent of the woody biomass was in stands where prospective energy wood could be harvested in harmony with conventional forestry practices and opportunities for enhancing future timber growth. The remaining 67 percent was in stands either exhibiting no treatment opportunity or on adverse sites.

More than 11 percent of the biomass was in rough and rotten trees and could be removed without adversely affecting existing supplies of sawtimber. Over 40 percent of the woody biomass in rough and rotten trees was in the boles of trees 5.0 inches d.b.h. and larger; 60 percent was in saplings, stumps, tops, and limbs.

Given a few reasonable assumptions about the removal of biomass from recently harvested stands and poorly stocked stands, an estimated 12.8 million tons of woody biomass could be harvested annually in North Carolina over the next two decades without adversely affecting timber supplies. The green weight of this energy wood is about 59 percent of the total green weight of harvest of industrial roundwood in North Carolina for 1983.

For all management classes, fully stocked stands on good sites yield about nine times more biomass than the poorly stocked stands on poor sites. Fully stocked pine stands on good sites can produce 100 tons of forest biomass per acre in 30 years, but oak-pine and hardwood stands with the same stocking and site criteria take 40 years.

Reserved timberland and woodland make up about 2 percent of the land area in North Carolina and support over 52 million tons of woody biomass, or an average of 104 tons per acre. Of the 0.5 million acres of reserved timberland and woodland, over 91 percent is classified as reserved timberland. Oak-hickory is the leading forest type and accounts for over two-thirds of the biomass. By forest type, the average tons per acre ranged from a low of 74 for spruce-fir stands to a high of 157 for white pine-hemlock.

Of the 12.3 million acres of nonforest land in North Carolina, about one-third supports woody biomass. Land for nonforest uses having woody biomass averaged from 5.9 to 40.4 tons per acre when sample plots were stratified by crown closure. Yellow pine is the leading species in terms of total biomass. By land use, urban and other supported the largest amount of total biomass.

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Table 1.--Area of timberland, by broad management and stand-age classes, North Carolina, 1984

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Acres										
Pine plantation	1,613,802	623,321	652,580	313,907	20,012	3,982	--	--	--	--	--
Natural pine	4,731,074	416,511	641,403	846,785	1,018,874	780,866	538,365	285,873	99,696	45,551	57,150
Oak-pine	2,276,670	386,313	264,276	176,251	331,159	361,589	334,055	244,531	108,533	33,384	36,579
Upland hardwood	7,124,854	956,524	438,478	501,253	819,750	1,061,483	1,191,477	858,767	609,005	284,999	403,118
Lowland hardwood	2,703,869	271,125	238,897	236,463	261,233	431,898	399,954	285,280	190,574	171,523	216,922
All classes	18,450,269	2,653,794	2,235,634	2,074,659	2,451,028	2,639,818	2,463,851	1,674,451	1,007,808	535,457	713,769

Table 2.--Average green weight of conventional growing stock[a] per acre of timberland, by broad management and stand-age classes, North Carolina, 1984

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Pine plantation	28.7	1.7	33.5	68.6	62.7	(b)	--	--	--	--	--
Natural pine	61.8	5.9	25.6	53.5	72.6	80.2	83.1	98.3	88.5	101.9	93.9
Oak-pine	52.5	9.9	21.8	38.9	53.7	67.7	73.6	76.0	97.8	100.1	101.6
Upland hardwood	62.4	11.2	24.8	36.3	56.0	68.3	77.8	92.2	90.4	86.0	87.0
Lowland hardwood	71.5	8.3	17.0	31.3	53.6	78.7	87.7	100.0	104.3	106.9	136.7
All classes	59.4	7.7	26.4	47.9	62.4	73.5	80.0	92.2	93.7	94.9	103.4

[a]Includes wood and bark between a 1-foot stump and 4-inch top d.o.b. in growing-stock trees 5.0 inches d.b.h. and larger.

[b]Sample was too small to provide a reliable estimate.

Table 3.--Average green weight of forest biomass per acre of timberland, by broad management and stand-age classes, North Carolina, 1984

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Pine plantation	45.9	8.1	57.1	93.4	81.9	(a)	--	--	--	--	--
Natural pine	87.9	12.0	50.6	81.7	100.8	108.8	110.6	128.4	119.3	130.9	130.0
Oak-pine	80.2	18.5	46.7	68.3	83.4	101.0	106.7	108.1	136.6	145.3	138.3
Upland hardwood	93.4	23.9	52.3	65.1	86.7	101.4	111.5	128.8	129.0	124.8	126.7
Lowland hardwood	109.5	18.0	40.7	62.1	91.3	118.0	128.9	145.0	150.2	157.8	199.7
All classes	88.6	16.9	51.3	76.1	92.6	106.4	113.5	128.5	132.9	137.2	149.8

[a]Sample was too small to provide a reliable estimate.

Table 4.--Area of timberland treated or disturbed annually and retained in timberland, by treatment or disturbance and broad management class, North Carolina, 1974 to 1984

Recent past treatment or disturbance	All management classes	Broad management class[a]				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
	Acres					
Harvesting followed by artificial regeneration	53,158	1,335	30,248	7,137	14,283	155
Other harvesting	206,618	1,322	92,015	27,601	61,114	24,566
Selection cutting and high grading	60,366	680	12,573	10,149	25,300	11,664
Commercial thinning	29,859	10,570	12,938	1,736	3,306	1,309
Other cutting[b]	51,564	1,286	13,129	5,862	28,509	2,778
Natural disturbance	196,649	15,187	86,729	24,359	45,423	24,951

[a]Classification before treatment or disturbance.

[b]Includes stand improvement, cleaning, release, intermediate cutting, and other miscellaneous treatments.

Table 5.--Average green weight of forest biomass per acre of timberland, by treatment or disturbance and broad management class, North Carolina, 1974 to 1984

Recent past treatment or disturbance	All management classes	Broad management class[a]				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
	Tons/acre					
Harvesting followed by artificial regeneration	6.2	9.1	6.1	6.5	6.0	15.1
Other harvesting	24.2	12.8	18.3	27.5	29.7	28.1
Selection cutting and high grading	83.1	47.0	78.0	92.2	77.1	101.2
Commercial thinning	75.4	77.3	71.8	--	79.4	90.0
Other cutting[b]	85.4	42.6	90.7	58.5	89.8	92.5
Natural disturbance	103.1	65.1	102.4	107.1	112.1	105.6

[a]Classification before treatment or disturbance.

[b]Includes stand improvement, cleaning, release, intermediate cutting, and other miscellaneous treatments.

Table 6.--Area of timberland, by treatment opportunity and broad management classes, North Carolina, 1984

Treatment opportunity class	All management classes	Broad management class				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
	Acres					
Salvage	59,399	900	30,697	13,260	8,128	6,414
Harvest	1,907,561	--	490,821	267,252	688,932	460,556
Commercial thinning	868,775	290,753	508,332	12,555	26,941	30,194
Other stand improvement	1,364,701	48,997	347,604	236,498	514,086	217,516
Stand conversion	217,526	7,376	19,712	14,442	118,970	57,026
Regeneration	2,022,545	14,049	454,000	309,307	797,494	447,695
None[a]	9,162,776	1,233,207	2,659,422	1,222,788	2,983,983	1,063,376
Adverse sites[b]	2,846,986	18,520	220,486	200,568	1,986,320	421,092
All stands	18,450,269	1,613,802	4,731,074	2,276,670	7,124,854	2,703,869

[a]Immature stands sufficiently stocked with growing-stock trees relatively free from damage or competition.

[b]Areas where harvesting and timber management opportunities are severely limited because of either steep slopes or water problems.

Table 7.--Average green weight of forest biomass per acre of timberland, by treatment opportunity and broad management classes, North Carolina, 1984

Treatment opportunity class	All management classes	Broad management class				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
	Tons/acre					
Salvage	123.2	(a)	145.7	106.0	94.1	104.9
Harvest	141.1	--	143.0	136.1	134.6	151.7
Commercial thinning	123.9	100.1	131.2	137.8	161.9	190.0
Other stand improvement	57.2	38.9	59.5	51.2	57.8	62.8
Stand conversion	54.7	24.3	39.3	48.4	62.9	48.5
Regeneration	33.2	16.1	16.5	33.4	39.0	40.4
None[b]	82.1	32.8	83.8	81.0	92.7	106.1
Adverse sites[c]	119.7	115.9	102.9	104.0	112.2	171.9
All stands	88.6	45.9	87.9	80.2	93.4	109.5

[a]Sample was too small to provide a reliable estimate.

[b]Immature stands sufficiently stocked with growing-stock trees relatively free from damage or competition.

[c]Areas where harvesting and timber management opportunities are severely limited because of either steep slopes or water problems.

Table 8.--Green weight and percentage distribution of wood and bark biomass on timberland, by major species group and biomass component, North Carolina, 1984

Biomass component	All species	Species group				
		Yellow pine	Other softwood	Soft hardwood	Oaks	Other hardwoods
	Percent of green weight					
Growing stock						
Bole	67.1	77.9	74.5	64.2	69.1	44.8
Stumps, tops, and limbs	14.3	14.3	15.3	12.9	18.0	10.9
Saplings	7.7	7.0	6.4	11.0	5.2	6.2
Total	89.1	99.2	96.2	88.1	92.3	61.9
Rough & rotten						
Bole	4.4	.3	2.4	5.4	4.1	12.2
Stumps, tops, and limbs	1.6	.1	.9	1.7	1.4	5.0
Saplings	4.9	.4	.5	4.8	2.2	20.9
Total	10.9	.8	3.8	11.9	7.7	38.1
All classes	100.0	100.0	100.0	100.0	100.0	100.0
Green weight (million tons)	1,638.4	458.9	64.6	500.9	380.1	233.9

Table 9.--Percentage distribution of forest biomass per acre of timberland, by species group and by broad management and stand-age classes, North Carolina, 1984

Broad management class and species group	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Percent										
Pine plantation											
Yellow pine	83	81	85	85	63	--	--	--	--	--	--
Other softwoods	4	--	2	5	25	70	--	--	--	--	--
Oaks	3	7	3	3	--	--	--	--	--	--	--
Other hardwoods	10	12	10	7	12	30	--	--	--	--	--
All species	100	100	100	100	100	100	--	--	--	--	--
Natural pine											
Yellow pine	73	72	76	78	78	73	73	66	67	73	41
Other softwoods	4	2	4	2	3	5	3	8	5	--	22
Oaks	7	5	5	5	5	7	9	9	9	7	16
Other hardwoods	16	21	15	15	14	15	15	17	19	20	21
All species	100	100	100	100	100	100	100	100	100	100	100
Oak-pine											
Yellow pine	34	36	40	42	34	33	32	32	32	21	29
Other softwoods	6	4	2	1	6	6	7	6	7	11	12
Oaks	25	28	20	17	21	27	28	25	25	27	22
Other hardwoods	35	32	38	40	39	34	33	37	36	41	37
All species	100	100	100	100	100	100	100	100	100	100	100
Upland hardwood											
Yellow pine	4	6	7	7	4	5	4	3	4	2	1
Other softwoods	2	2	1	1	1	1	2	2	1	2	2
Oaks	42	30	29	30	32	37	42	46	53	52	57
Other hardwoods	52	62	63	62	63	57	52	49	42	44	40
All species	100	100	100	100	100	100	100	100	100	100	100
Lowland hardwood											
Yellow pine	3	4	6	6	4	4	3	2	3	2	1
Other softwoods	8	5	3	7	3	3	5	7	13	13	16
Oaks	9	16	5	9	9	9	10	9	13	8	8
Other hardwoods	80	75	86	78	84	84	82	82	71	77	75
All species	100	100	100	100	100	100	100	100	100	100	100

Table 10.--Percentage distribution of forest biomass per acre of timberland, by tree diameter, broad management, and stand-age classes, North Carolina, 1984

Broad management and diameter classes (inches)	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Percent										
Pine plantation											
1.0 - 4.9	21	69	23	11	8	2	--	--	--	--	--
5.0 - 8.9	51	23	63	42	30	20	--	--	--	--	--
9.0 - 12.9	23	3	12	39	53	29	--	--	--	--	--
13.0+	5	5	2	8	9	49	--	--	--	--	--
All classes	100	100	100	100	100	100	--	--	--	--	--
Natural pine											
1.0 - 4.9	14	36	36	19	13	10	10	8	11	8	6
5.0 - 8.9	28	30	40	40	32	25	18	14	13	11	13
9.0 - 12.9	30	22	17	27	34	34	32	29	23	29	15
13.0+	28	12	7	14	21	31	40	49	53	52	66
All classes	100	100	100	100	100	100	100	100	100	100	100
Oak-pine											
1.0 - 4.9	15	28	37	27	17	12	12	11	9	8	7
5.0 - 8.9	22	24	30	31	29	23	17	17	12	14	13
9.0 - 12.9	26	26	17	27	30	29	29	23	20	18	13
13.0+	37	22	16	15	24	36	42	49	59	60	67
All classes	100	100	100	100	100	100	100	100	100	100	100
Upland hardwood											
1.0 - 4.9	11	30	33	22	14	11	8	6	6	6	6
5.0 - 8.9	18	30	26	31	27	23	16	13	14	12	10
9.0 - 12.9	25	22	22	25	28	29	27	24	22	18	17
13.0+	46	18	19	22	31	37	49	57	58	64	67
All classes	100	100	100	100	100	100	100	100	100	100	100
Lowland hardwood											
1.0 - 4.9	11	32	35	25	14	11	9	7	6	7	5
5.0 - 8.9	17	30	27	31	28	19	17	14	9	13	9
9.0 - 12.9	22	20	16	22	28	26	24	23	16	18	18
13.0+	50	18	22	22	30	44	50	56	69	62	68
All classes	100	100	100	100	100	100	100	100	100	100	100

Table 11.--Area of timberland supporting pine plantations, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)[a]				
		0-10	11-20	21-30	31-40	41-50
	Acres					
Good sites						
Fully stocked	388,093	85,963	160,053	129,779	8,316	3,982
Medium stocked	85,426	24,695	14,955	38,867	6,909	--
Poorly stocked	5,439	2,152	3,287	--	--	--
All stands	478,958	112,810	178,295	168,646	15,225	3,982
Medium sites						
Fully stocked	804,031	323,536	348,818	126,890	4,787	--
Medium stocked	207,854	124,445	79,177	4,232	--	--
Poorly stocked	29,130	14,484	14,646	--	--	--
All stands	1,041,015	462,465	442,641	131,122	4,787	--
Poor sites						
Fully stocked	62,502	28,415	24,058	10,029	--	--
Medium stocked	29,144	19,631	7,586	1,927	--	--
Poorly stocked	2,183	--	--	2,183	--	--
All stands	93,829	48,046	31,644	14,139	--	--
All sites						
Fully stocked	1,254,626	437,914	532,929	266,698	13,103	3,982
Medium stocked	322,424	168,771	101,718	45,026	6,909	--
Poorly stocked	36,752	16,636	17,933	2,183	--	--
All stands	1,613,802	623,321	652,580	313,907	20,012	3,982

[a]More than 98 percent of pine plantations were less than 31 years old.

Table 12.--Area of timberland supporting natural pine stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Acres										
Good sites											
Fully stocked	1,368,424	45,864	130,096	256,127	368,076	246,267	189,384	88,385	23,383	18,042	2,845
Medium stocked	252,225	7,625	26,435	51,831	74,115	49,433	25,941	13,980	2,865	--	--
Poorly stocked	34,126	22,433	2,487	6,662	2,544	--	--	--	--	--	--
All stands	1,654,775	75,922	159,018	314,620	444,735	295,700	215,325	102,365	26,203	18,042	2,845
Medium sites											
Fully stocked	1,549,103	147,525	289,976	312,474	279,776	248,966	120,462	88,361	28,889	10,083	22,591
Medium stocked	442,590	42,807	54,985	66,664	84,488	89,721	48,536	17,572	10,352	12,022	15,443
Poorly stocked	115,596	57,2	9,589	11,383	8,381	5,245	17,994	5,801	--	--	--
All stands	2,107,289	247,535	354,550	390,521	372,645	343,932	186,992	111,734	39,241	22,105	38,034
Poor sites											
Fully stocked	460,196	39,816	75,847	80,966	94,758	68,426	38,321	32,669	20,406	--	8,987
Medium stocked	281,983	20,965	37,468	26,297	78,462	43,105	36,372	23,758	13,846	1,710	--
Poorly stocked	226,831	32,273	14,520	34,381	28,274	29,703	61,355	15,347	--	3,694	7,284
All stands	969,010	93,054	127,835	141,644	201,494	141,234	136,048	71,774	34,252	5,404	16,271
All sites											
Fully stocked	3,377,723	233,205	495,919	649,567	742,610	563,659	348,167	209,415	72,633	28,125	34,423
Medium stocked	976,798	71,397	118,888	144,792	237,065	182,259	110,849	55,310	27,063	13,732	15,443
Poorly stocked	376,553	111,909	26,596	252,426	39,199	34,948	79,349	21,148	--	3,694	7,284
All stands	4,731,074	416,511	641,403	846,785	1,018,874	780,866	538,365	285,873	99,696	45,551	57,150

Table 13.--Area of timberland supporting oak-pine stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Acres										
Good sites											
Fully stocked	620,033	91,543	45,913	37,852	79,375	120,479	98,190	76,544	40,374	16,017	13,746
Medium stocked	207,580	16,423	11,485	2,896	38,136	35,521	41,197	33,951	14,485	9,869	3,617
Poorly stocked	1,012	--	--	--	1,012	--	--	--	--	--	--
All stands	828,625	107,966	57,398	40,748	118,523	156,000	139,387	110,495	54,859	25,886	17,363
Medium sites											
Fully stocked	779,861	195,176	107,195	80,504	109,132	111,562	89,946	51,285	22,276	--	12,785
Medium stocked	312,200	20,149	44,059	32,525	42,372	55,691	46,929	38,612	27,831	4,032	--
Poorly stocked	65,597	26,094	12,670	6,639	5,965	6,818	4,032	3,379	--	--	--
All stands	1,157,658	241,419	163,924	119,668	157,469	174,071	140,907	93,276	50,107	4,032	12,785
Poor sites											
Fully stocked	150,241	18,374	27,313	15,835	16,545	16,481	37,777	10,883	3,567	3,466	--
Medium stocked	115,166	18,554	15,641	--	25,024	15,037	9,319	25,160	--	--	6,431
Poorly stocked	24,980	--	--	--	13,598	--	6,665	4,717	--	--	--
All stands	290,387	36,928	42,954	15,835	55,167	31,518	53,761	40,760	3,567	3,466	6,431
All sites											
Fully stocked	1,550,135	305,093	180,421	134,191	205,052	248,522	225,913	138,712	66,217	19,483	26,531
Medium stocked	634,946	55,126	71,185	35,421	105,532	106,249	97,445	97,723	42,316	13,901	10,048
Poorly stocked	91,589	26,094	12,670	6,639	20,575	6,818	10,697	8,096	--	--	--
All stands	2,276,670	386,313	264,276	176,251	331,159	361,589	334,055	244,531	108,533	33,384	36,579

Table 14.--Area of timberland supporting upland hardwood stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Acres										
Good sites											
Fully stocked	1,632,487	163,019	67,803	61,865	223,143	276,643	336,883	258,621	135,088	62,307	47,115
Medium stocked	916,559	33,082	30,392	66,128	137,296	202,565	187,936	116,988	80,916	17,019	44,237
Poorly stocked	121,421	42,811	12,681	12,155	14,890	16,783	14,371	3,982	3,74	--	--
All stands	2,670,467	238,912	110,876	140,148	375,329	495,991	539,190	379,591	219,752	79,326	91,352
Medium sites											
Fully stocked	2,030,060	442,972	170,145	136,037	204,239	245,046	269,845	191,628	177,870	75,085	117,193
Medium stocked	1,465,684	110,095	113,126	151,194	172,155	199,496	267,558	187,921	112,310	74,652	77,177
Poorly stocked	219,230	79,081	14,766	16,215	26,259	29,611	10,255	20,384	10,268	--	12,391
All stands	3,714,974	632,148	298,037	303,446	402,653	474,153	547,658	399,933	300,448	149,737	206,761
Poor sites											
Fully stocked	362,949	61,310	18,314	32,106	24,143	48,224	56,152	37,432	33,494	17,609	34,165
Medium stocked	323,800	15,960	11,251	17,192	14,716	36,427	36,838	37,779	51,811	34,419	66,407
Poorly stocked	52,664	8,194	--	8,361	2,909	5,688	11,639	4,032	3,500	3,908	4,433
All stands	739,413	85,464	29,565	57,659	41,769	91,339	104,629	79,243	88,805	55,936	105,005
All sites											
Fully stocked	4,025,496	667,301	256,262	230,008	451,525	569,913	662,880	487,681	346,452	155,001	198,473
Medium stocked	2,706,043	159,137	154,769	234,514	324,167	439,488	492,332	342,688	245,037	126,090	187,821
Poorly stocked	393,315	130,086	27,447	36,731	44,058	52,082	36,265	28,398	17,516	3,908	16,824
All stands	7,124,854	956,524	438,478	501,253	819,750	1,061,483	1,191,477	858,767	609,005	284,999	403,118

Table 15.--Area of timberland supporting lowland hardwood stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Acres										
Good sites											
Fully stocked	697,828	60,709	29,121	39,324	74,199	171,464	110,364	91,879	57,030	39,244	24,494
Medium stocked	270,284	21,523	8,532	30,917	40,863	41,189	46,035	38,171	22,897	9,387	10,770
Poorly stocked	52,488	5,351	6,908	13,546	14,662	3,351	2,655	2,844	3,171	--	--
All stands	1,020,600	87,583	44,561	83,787	129,724	216,004	159,054	132,894	83,098	48,631	35,264
Medium sites											
Fully stocked	1,033,120	80,966	69,596	68,564	83,207	109,343	158,385	123,504	87,224	99,746	152,585
Medium stocked	337,684	32,457	55,108	32,128	22,346	66,973	59,943	17,190	12,841	17,273	21,425
Poorly stocked	67,094	35,672	10,658	9,631	2,654	8,479	--	--	--	--	--
All stands	1,437,898	149,095	135,362	110,323	108,207	184,795	218,328	140,694	100,065	117,019	174,010
Poor sites											
Fully stocked	121,467	15,279	25,300	25,206	2,965	17,844	13,037	4,834	3,481	5,873	7,648
Medium stocked	73,331	6,024	22,294	6,925	12,610	8,280	6,410	6,858	3,930	--	--
Poorly stocked	50,573	13,144	11,380	10,222	7,727	4,975	3,125	--	--	--	--
All stands	245,371	34,447	58,974	42,353	23,302	31,099	22,572	11,692	7,411	5,873	7,648
All sites											
Fully stocked	1,852,415	156,954	124,017	133,094	160,371	298,651	281,786	220,217	147,735	144,863	184,727
Medium stocked	681,299	60,004	85,934	69,970	75,819	116,442	112,388	62,219	39,668	26,660	32,195
Poorly stocked	170,155	54,167	28,946	33,399	25,043	16,805	5,780	2,844	3,171	--	--
All stands	2,703,869	271,125	238,897	236,463	261,233	431,898	399,954	285,280	190,574	171,523	216,922

Table 16.--Average green weight of forest biomass per acre of timberland supporting pine plantations, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)[a]				
		0-10	11-20	21-30	31-40	41-50
	Tons/acre					
Good sites						
Fully stocked	74.3	11.1	71.5	114.7	95.2	192.3
Medium stocked	49.0	8.8	51.3	69.4	72.7	--
Poorly stocked	9.1	(b)	12.6	--	--	--
All stands	69.1	10.5	68.7	104.3	85.0	192.3
Medium sites						
Fully stocked	43.9	8.6	60.5	87.2	72.3	--
Medium stocked	17.4	5.6	34.4	45.7	--	--
Poorly stocked	10.6	3.9	17.2	--	--	--
All stands	37.7	7.7	54.4	85.9	72.3	--
Poor sites						
Fully stocked	22.7	6.7	33.0	43.4	--	--
Medium stocked	9.8	6.9	14.3	(b)	--	--
Poorly stocked	(b)	--	--	(b)	--	--
All stands	18.2	6.8	28.5	33.7	--	--
All sites						
Fully stocked	52.3	9.0	62.6	98.9	86.8	192.3
Medium stocked	25.1	6.2	35.4	65.1	72.7	--
Poorly stocked	9.7	3.9	16.3	--	--	--
All stands	45.9	8.1	57.1	93.4	81.9	192.3

[a]More than 98 percent of pine plantations were less than 31 years old.

[b]Sample was too small to provide a reliable estimate.

Table 17.--Average green weight of forest biomass per acre of timberland supporting natural pine stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Good sites											
Fully stocked	131.3	25.0	69.5	117.6	137.8	146.2	151.5	183.4	179.6	158.4	(a)
Medium stocked	84.4	11.8	51.0	61.5	88.3	104.7	113.9	112.3	(a)	--	--
Poorly stocked	12.6	--	(a)	29.8	(a)	--	--	--	--	--	--
All stands	121.7	16.3	66.4	106.5	129.0	139.3	147.0	173.7	176.1	158.4	(a)
Medium sites											
Fully stocked	92.5	16.8	58.1	87.9	109.8	116.6	128.0	139.6	126.0	182.8	151.8
Medium stocked	61.8	12.4	24.3	50.3	64.5	75.7	84.8	81.7	125.9	69.0	143.3
Poorly stocked	13.7	.6	17.5	6.5	16.9	62.8	34.5	36.9	--	--	--
All stands	81.7	12.3	51.8	79.2	97.4	105.1	107.8	125.2	126.0	120.9	148.4
Poor sites											
Fully stocked	62.4	16.1	37.0	44.8	68.7	74.3	104.9	96.1	97.8	--	98.3
Medium stocked	36.4	3.2	17.3	38.5	29.8	43.4	70.1	48.2	24.5	(a)	--
Poorly stocked	14.3	--	5.2	4.6	8.4	22.1	18.5	42.8	--	(a)	27.1
All stands	43.6	7.6	27.6	33.9	45.1	53.9	56.6	68.9	68.2	(a)	66.4
All sites											
Fully stocked	104.1	18.3	57.9	94.3	118.5	124.4	138.3	151.3	135.3	167.1	145.8
Medium stocked	60.3	9.6	28.0	52.2	60.4	75.9	86.8	75.1	76.4	82.4	143.4
Poorly stocked	14.0	.3	15.3	8.2	11.4	28.2	22.1	41.2	--	34.9	27.1
All stands	87.9	12.0	50.6	81.7	100.8	108.8	110.6	128.4	119.3	130.9	130.0

[a]Sample was too small to provide a reliable estimate.

Table 18.--Average green weight of forest biomass per acre of timberland supporting oak-pine stands, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Good sites											
Fully stocked	118.1	26.2	66.2	90.4	124.3	128.5	155.7	148.1	176.5	177.6	176.2
Medium stocked	92.7	13.4	47.9	(a)	81.8	91.0	112.3	118.4	98.9	137.7	(a)
Poorly stocked	(a)	--	--	--	(a)	--	--	--	--	--	(a)
All stands	111.6	24.3	62.5	94.0	109.5	120.0	142.9	139.0	156.0	162.4	155.1
Medium sites											
Fully stocked	72.8	20.3	51.6	69.7	85.7	106.8	96.7	121.8	154.5	--	158.9
Medium stocked	65.0	9.4	40.1	50.3	78.5	68.6	92.0	69.0	82.4	71.8	--
Poorly stocked	19.6	1.7	11.8	43.0	29.6	41.9	57.5	32.7	--	--	--
All stands	67.7	17.4	45.5	62.9	81.6	92.0	94.0	96.7	114.4	71.8	158.9
Poor sites											
Fully stocked	47.3	12.2	31.2	43.1	41.3	73.5	48.7	65.9	149.8	(a)	--
Medium stocked	36.6	6.3	28.0	--	38.2	38.3	57.6	50.1	--	--	51.7
Poorly stocked	12.7	--	--	--	9.6	--	17.0	15.3	--	--	--
All stands	40.1	9.2	30.1	43.1	32.1	56.7	46.3	50.3	149.8	(a)	51.7
All sites											
Fully stocked	88.5	21.6	52.2	72.4	97.0	115.1	114.3	131.9	167.7	164.4	168.9
Medium stocked	68.9	9.6	38.7	57.7	70.1	71.8	97.3	81.3	88.0	118.6	60.1
Poorly stocked	17.5	1.7	11.8	43.0	14.9	41.9	32.2	22.5	--	--	--
All stands	80.2	18.5	46.7	68.3	83.4	101.0	106.7	108.1	136.6	145.3	138.3

[a]Sample was too small to provide a reliable estimate.

Table 19.--Average green weight of forest biomass per acre of timberland supporting upland hardwood, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Good sites											
Fully stocked	131.7	31.5	63.7	99.8	116.5	144.1	145.3	168.5	167.5	165.9	170.3
Medium stocked	99.6	29.4	70.9	69.9	80.3	91.0	113.7	111.2	145.0	118.6	134.6
Poorly stocked	35.5	9.7	24.4	19.1	59.9	55.8	43.4	112.3	121.1	--	--
All stands	116.3	27.3	61.9	78.7	101.0	119.4	131.6	150.2	158.4	155.8	153.0
Medium sites											
Fully stocked	91.7	28.0	53.8	71.7	89.0	101.2	123.8	133.7	139.5	139.1	149.7
Medium stocked	75.4	18.0	47.1	57.6	66.2	80.5	76.6	104.0	92.0	100.7	117.8
Poorly stocked	31.5	2.5	12.6	22.4	36.1	53.2	55.2	66.7	64.0	--	85.5
All stands	81.7	23.1	49.2	62.0	75.8	89.5	99.4	116.3	119.2	120.0	133.9
Poor sites											
Fully stocked	76.7	20.9	55.6	58.9	71.1	73.5	84.6	94.4	126.4	137.3	101.5
Medium stocked	69.9	29.7	40.5	42.2	59.9	62.3	66.0	87.5	70.0	77.1	86.3
Poorly stocked	21.5	1.2	--	20.8	(a)	9.0	19.9	52.8	22.0	43.9	46.6
All stands	69.8	20.6	49.9	48.4	62.2	64.9	60.8	89.0	89.4	93.8	89.6
All sites											
Fully stocked	106.6	28.2	56.6	77.5	101.6	119.7	131.4	149.1	149.2	150.0	146.3
Medium stocked	82.9	21.5	51.3	59.9	71.9	83.8	90.0	104.7	104.8	96.7	110.6
Poorly stocked	31.4	4.8	18.0	20.9	41.8	49.2	39.2	71.1	67.8	43.9	75.2
All stands	93.4	23.9	52.3	65.1	86.7	101.4	111.5	128.8	129.0	124.8	126.7

[a]Sample was too small to provide a reliable estimate.

Table 20.--Average green weight of forest biomass per acre of timberland supporting lowland hardwood, by site, stocking, and stand-age classes, North Carolina, 1984

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
	Tons/acre										
Good sites											
Fully stocked	146.9	25.3	68.0	93.9	131.8	150.4	161.9	193.0	171.4	216.8	240.1
Medium stocked	81.7	16.2	46.1	62.7	76.2	87.8	107.6	94.9	90.5	125.5	79.0
Poorly stocked	33.8	3.9	11.2	24.4	29.7	88.6	83.2	(a)	(a)	--	--
All stands	123.9	21.8	55.0	71.2	102.7	137.5	144.9	161.9	145.3	199.1	190.9
Medium sites											
Fully stocked	131.3	22.6	52.6	81.5	100.4	130.1	141.8	135.9	171.6	149.8	215.5
Medium stocked	62.8	14.7	38.1	55.2	57.9	73.1	73.5	86.5	86.4	79.1	107.3
Poorly stocked	17.6	10.5	8.3	26.3	(a)	46.6	--	--	--	--	--
All stands	109.9	18.0	43.2	69.0	89.8	105.6	123.1	129.9	160.7	139.4	202.2
Poor sites											
Fully stocked	68.0	18.2	36.4	24.7	(a)	73.2	94.7	181.3	(a)	182.0	184.7
Medium stocked	36.0	.2	22.1	43.1	29.2	36.2	44.4	104.1	(a)	--	--
Poorly stocked	12.8	1.3	1.9	17.5	23.5	23.4	(a)	--	--	--	--
All stands	47.1	8.6	24.3	26.0	34.2	55.4	73.2	136.0	63.3	182.0	184.7
All sites											
Fully stocked	133.1	23.2	52.9	74.4	114.6	138.4	147.5	160.7	169.4	169.3	217.5
Medium stocked	67.4	13.8	34.7	57.3	63.0	75.7	85.8	93.6	84.8	95.4	97.8
Poorly stocked	21.2	7.6	6.5	22.8	27.3	48.1	61.3	(a)	(a)	--	--
All stands	109.5	18.0	40.7	62.1	91.2	118.0	128.9	145.0	150.2	157.8	199.7

[a]Sample was too small to provide a reliable estimate.

Table 21.--Area and green weight of woody biomass per acre of timberland, by forest type, North Carolina, 1984

Forest type	All lands	Reserved timberland	Woodland	All lands	Reserved timberland	Woodland
	----- Acres -----			---- Tons/acres ----		
Spruce-fir	9,525	9,525	--	74.3	74.3	--
White pine-hemlock	18,713	18,713	--	156.8	156.8	--
Loblolly-shortleaf pine	62,185	54,293	7,892	128.7	147.3	.5
Oak-pine	3,209	3,209	--	79.1	79.1	--
Oak-hickory	327,691	313,819	13,872	98.2	102.1	10.8
Oak-gum-cypress	43,837	22,792	21,045	89.5	154.4	19.3
Maple-beech-birch	37,427	37,427	--	119.5	119.5	--
All types	502,587	459,778	42,809	104.4	112.9	13.1

Table 22.--Area of nonforest land, by land use and percent crown closure, North Carolina, 1984

Land use	All classes	Percent crown closure class		
		1-29	30-59	60+
		Acres		
Cropland	740,659	634,589	85,655	20,415
Improved pasture	663,487	537,114	88,864	37,509
Idle farmland	167,327	144,064	12,009	11,254
Other farmland	326,161	208,478	82,837	34,846
Urban and other	1,689,021	1,080,189	409,932	198,900
Marsh	30,418	30,418	--	--
Noncensus water	43,479	29,873	13,606	--
All uses	3,660,552	2,664,725	692,903	302,924

Table 23.--Per acre green weight of wood and bark biomass associated with nonforest land, by land use and percent crown closure, North Carolina, 1984

Land use	All classes	Percent crown closure class		
		1-29	30-59	60+
	Tons/acre			
Cropland	8.0	4.6	18.9	68.3
Improved pasture	12.3	10.0	24.1	18.5
Idle farmland	9.5	8.0	20.3	17.3
Other farmland	11.7	3.9	20.9	36.8
Urban and other	13.7	4.6	23.2	43.6
Marsh	6.5	6.5	--	--
Noncensus water	11.6	9.8	15.5	--
All uses	11.9	5.9	22.3	40.4

Table 24.--Total green weight of aboveground wood and bark biomass on nonforest land, by land use and species group, North Carolina, 1984

Land use	All classes	Yellow pine	Other softwoods	Soft hardwood	Oaks	Other hard hardwood	Noncommercial
				Tons			
Cropland	5,914,442	1,309,327	327,243	2,569,539	1,011,485	583,154	113,694
Improved pasture	8,183,868	1,027,013	335,099	3,321,727	1,594,288	1,758,169	147,572
Idle farmland	1,593,862	163,461	94,302	221,693	1,031,583	39,248	43,575
Other farmland	3,823,543	397,497	75,537	236,483	2,111,582	846,149	156,295
Urban and other	23,199,626	11,270,730	450,052	3,260,192	6,157,037	1,504,218	557,397
Marsh	197,913	29,537	--	47,079	121,297	--	--
Noncensus water	503,509	21,974	--	133,789	347,746	--	--
All uses	43,416,763	14,219,539	1,282,233	9,790,502	12,375,018	4,730,938	1,018,533

Cost, Noel D.
Multiresource inventories: woody biomass in North Carolina. Res. Pap. SE-261. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1986. 36 pp.

North Carolina's 31.2 million acres of land area support 1.7 billion tons of woody biomass. Of this total, 94 percent is on timberland, 3 percent on nonforest areas, and 3 percent on reserved timberland and woodland areas. Over the next two decades, more than 12.8 million tons of woody biomass could be harvested annually from timberland without adversely affecting timber supplies.

KEYWORDS: Growing stock, timberland, multiple use.

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The Forest Service, U.S. Department of Agriculture, is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.